National Aeronautics and Space Administration

COVID-19 Exposure Assessment Tool (CEAT)

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Who is COV-IRT?

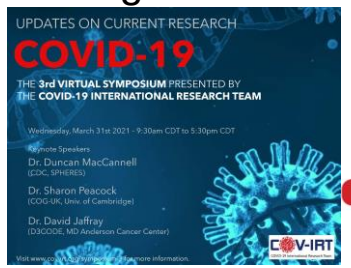
COVID-19 International Research Team

Initiative Setup to work on COVID-19: Started with scientists who are members with the NASA GeneLab Multi-Omics Analysis Working Group (AWG) that Dr. Beheshti leads.

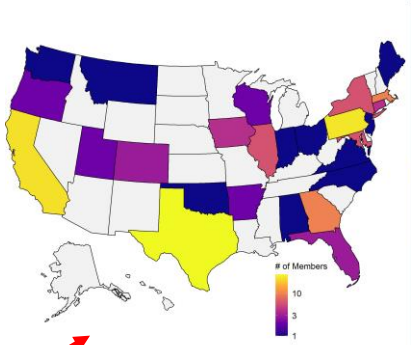
GeneLab Open Science for Life in Space

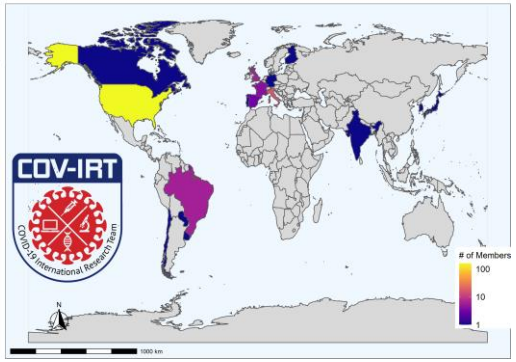
COV-IRT Organized Three COVID-19 Symposium

Recordings available for all symposiums



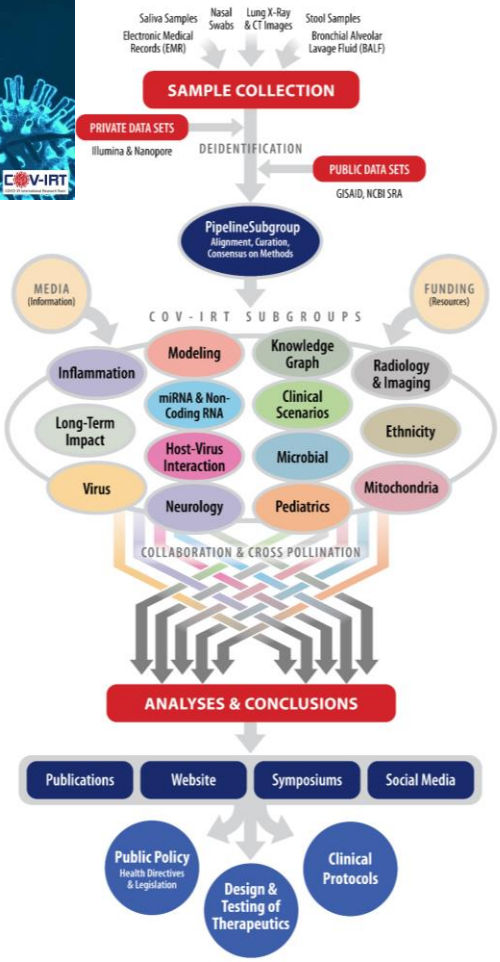
Current COV-IRT Members





History of COV-IRT

- Group started on 3/25/2020
- Lead of COV-IRT is: Afshin Beheshti
- Goal of COV-IRT to be Open Science!!
- Group has expanded to 200+ members
  - People from all around world have joined COV-IRT for the common goal of tackling COVID-19
- Members now working together in many different working subgroups to either model COVID dynamics in populations, predict drug targets, analyze omics data to determine potential targets for drug/vaccine development, and are currently testing a very promising anti-viral therapeutic against COVID-19.
- Therapeutics are in development and testing with *in vitro* and *in vivo* SARS-CoV-2 models with COV-IRT members
- Development of free tools to be made available to the public: **COVID-19 EXPOSURE ASSESSMENT TOOL (CEAT)!!**
- COV-IRT is also ready for future pandemics with the tools, network, and pipelines developed from COVID
- **COV-IRT became an independent nonprofit on 7/17/2020**



Start Step 1 Enter information that describes the Group.

a. Group's Infection Likelihood compared to the Community

The Group is composed of people who, prior to this activity, you estimate have a likelihood COVID-19 infection that is...	A	B
100x lower than the community's average due to their adhering to public health guidance on distancing, masking, and exposure to crowds/people.	☐	☐
10x lower than the community's average due to their adhering to public health guidance on distancing, masking, and exposure to crowds/people.	☐	☐
Equal to the community average.	■	■
10x higher than the community's average due to their not adhering to public health guidance on distancing, masking, and exposures to crowds.	☐	☐
100 percent, since they are known to be diagnosed with active COVID-19.	☐	☐

b. Group's Vaccination Rate: 100.00 % ☐ Click to apply Group's Vaccination Rate to the Exposure Calculations

c. Group members use of viral genome or protein surveillance testing

☐ All members are tested within 3-days prior to event ☐ All unvaccinated members are tested within 3-days prior to event ■ Testing not required (or testing status unknown)

Step 2 Enter the number of people sharing the space for the activity.

Must be between 2 and 250 people.

	A	B
Number of People Sharing Activity Space:	10	10

Step 3 Enter distance (Option 1) or select distance (Option 2)

Option 1 ft

A	3.00
B	3.00

Option 2 ~15 ft ~10 ft ~6 ft ~3 ft ~1.5 ft

Step 4 Select Mask Type and Prevalence of mask wearing

Filter Type	A	B	% of People Wearing Masks	A	B
Fitted N95	☐	☐	100%	☐	■
N95/KN95	☐	■	90%	☐	☐
Double Surgical Mask	☐	☐	75%	☐	☐
Surgical Mask	☐	☐	50%	☐	☐
Average Mask	☐	☐	25%	☐	☐
Cloth Mask	☐	☐	0%	■	☐
No Mask	■	☐			

Step 5 Select Vocalization Intensity

Activity	Exhalation Type	A	B
Resting	Silent	☐	☐
	Speaking	☐	☐
	Loudly speaking	☐	☐
Standing	Silent	☐	☐
	Speaking	■	■
	Loudly speaking	☐	☐
	Singing	☐	☐
Light exercise	Silent	☐	☐
	Speaking	☐	☐
	Loudly speaking	☐	☐
Heavy exercise	Silent	☐	☐
	Speaking	☐	☐
	Loudly speaking	☐	☐

Step 6 Select Breathing Rate

Activity	A	B
Sleep	☐	☐
Resting	☐	☐
Passive/Light Activity	■	■
Moderate Exertion	☐	☐
Heavy Exertion	☐	☐

Step 7 Enter the duration that most closely matches activity.

Duration of Activity in Hours:	A	B
	1.00	1.00

Step 8 Select whether outdoor or indoor

a. Outdoor: A: ○ B: ○ **Outdoor activities:** Select wind conditions that best match.

Beaufort Scale			A	B
Moderate	13 - 18 mph	Raises dust and loose paper; small branches are moved	☐	☐
Gentle	8 - 12 mph	Leaves/small twigs in constant motion, wind extends light flag	☐	☐
Light	4 - 7 mph	Wind felt on face, leaves rustle	☐	☐
Calm	1 - 3 mph	Direction of wind shown by smoke drift	☐	☐
Very Calm	0.1 - 1 mph	No direction or flow observed	■	■

b. Indoor: A: ● B: ●

Obtain the Air Changes per Hour (ACH) using Option 1 or 2:

- **Option 1** – Use ACH provided by building engineers or H&S.
- **Option 2** – from Table 1 on right, select the facility type and ACH that best matches the activity location.

Enter indoor ACH (or AER[1]) Values:

Indoor ACH	A	B
	6.00	6.00

[1] ACH (Air Changes per Hour) is synonymous with AER (Air Exchange Rate [Exchanges/Hour])

Table 1: Typical ACH Values (Option 2)

Medical	ACH
General	6
Laboratory	6
Treatment room	6
Examination room	6
Retail	
Sales (except as below)	1.5
Barbershop	1.5
Hair and nail salons	3.75
Supermarket	1
Fast Food	6
Bars	2 - 6
Restaurants	2 - 4
Education	
Classrooms (ages 5 to 8)	2
Classrooms (age 9 plus)	2
Daycare (through age 4)	2.5
Multiuse assembly	5
Lecture hall (fixed seats)	7
Lecture classroom	3
Libraries	1.5
Music/theater/dance	2.5
Office	
Office space	0.5
Reception Area	1.25
Meeting/ Conference Rooms	2
Manufacturing	
Manufacturing Floor	1.5
Residential	
Homes with closed windows	0.5
Rooms with one open window	1.75
Homes with all open windows	3
Travel	
Aircraft	20
Trains/Buses	6
Cars (Windows Closed)	6
Cars (Windows Open)	10

c. Room Filtration

	A	B
HEPA Filters	○	○
MERV 13	○	○
MERV 8	○	○
No Filters	●	○

Select Flowrate Option:

- ● **Flow Option 1** – Use a default assumption of flow of filtered air of 1 cfm/ft².
- ○ **Flow Option 2** – Enter a specific filtration flow rate if known

Flowrate (cfm): 0

Step 9 If indoors, enter the room dimensions and the height of the ceiling.

	A	B
Room Length (ft):	33.0	33.0
Room Width (ft):	33.0	33.0
Ceiling Height (ft):	9.00	9.00
Room Area (ft²)	1089	1089
Room Volume (ft³)	9801	9801

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CEAT COVID-19 Exposure Assessment Tool

Notes

Enter notes here

US Customary Units (US)

23 January 2022 V B.34_US BETA

Save As

Important: CEAT must be opened with Adobe Acrobat® or Adobe Reader® to function. See Page 2 for a technical summary and Page 3 for instructions.

Step 10 Calculate Adjustment to Local Community's Current Conditions

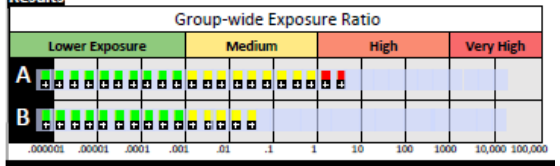
Average Daily Cases per 100,000 in the Last Week		Average Days Infectious (Set to 5 if not known)		Undiagnosed Factor for Area (Set to 3 if not known)		Active Infections per 100,000 [2]
36.50	→	5.00	→	5.0	=	909.2

Variant Prevalence: WHO Variant Label	Estimate of Portion of Active Infections (%)	Comparative Increased Transmission versus Wild-Type Virus (%)
Alpha	0.00	0.00
Beta	0.00	0.00
Delta	2.00	100.00
Omicron	98.00	940.00

Immunity Prevalence	
Population Vaccination Rate (%)	65.00
Population Recovered (%)	35.00
Protection Effectiveness of Immunity (%)	37.00
Correlation Factor	
Poisson Distribution Adjustment Factor	0.60

Results

Group-wide Exposure Ratio



	A	B
Group-wide Exposure Ratio:	2.2505	0.0450
Near Field:	2.0795	0.0415
Far Field:	0.1710	0.0034
Individual (Indv.) Exposure Ratio:	0.4501	0.0090
Indv. Dose (Quanta):	0.015	0.0003
Infect Rate:	3.2 %	0.0 %
# of Indiv. Infectors:	0.0821	0.0821

END Take actions to reduce exposure!

HIGH OR VERY HIGH: Make changes to reduce exposure. Rethink the event or activity. Combine multiple mitigations such as using N95 masks, increasing ventilation, holding event outside, greatly increasing distancing, reducing people, or shortening the duration

Disclaimer Statement:

By using this tool you agree to be bound by this disclaimer. This tool does not provide a prediction of the likelihood of infection or transmission of disease, nor does the tool provide advice or guarantee outcome. It solely provides a means for the user to estimate theoretical relative exposure. It is intended for informational purposes only and users should not rely on output for decision-making. Information is gathered from various sources and Signature Science, LLC, COV-IRT or its members are not responsible for errors or omissions in data. No warranties are given in relation to this tool and it is not guaranteed as fit for purpose.

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Molly Isbell

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The mastermind behind CEAT!!!

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https://www.cov-irt.org/exposure-assessment-tool/

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A Comparative Group-wide Dose Equation and Corresponding CEAT Model Steps

(Eq. 3)

RESULT:	Step 1: Step 10:	Step 5:	Step 2: Step 3: Step 8: Step 9: Step 7:	Step 4a:	Step 4b:	Step 6:	Step 2:	Step 7:	Step 10:	Step 1:
Group-wide Dose Ratio	Behavior of Sub Population; Local Epidem-iology	Emission of Virus	# of People; Dis-tancing; Venti-lation Rate; Indoor Room Dim.; Duration	Mask Effectiveness on Exhalation	Mask Effectiveness on Inhalation	Inhalation Rate	# of People	Duration	Local Epidemiology Factors	Behavior of Sub Population

$$\frac{\bar{D}_{\text{quanta } i}}{\bar{D}_{\text{quanta } BL}} = \frac{\varphi_i}{\varphi_{BL}} \times \frac{\dot{M}_i}{\dot{M}_{BL}} \times \frac{\sum_1^{Pe-1}(FF_{Factor\,i} + NF_{Factor\,i})}{\sum_1^{Pe-1}(FF_{Factor\,BL} + NF_{Factor\,BL})} \times \frac{(1 - Ef_{out})_i}{(1 - Ef_{out})_{BL}} \times \frac{(1 - Ef_{in})_i}{(1 - Ef_{in})_{BL}} \times \frac{Q_{inhale_i}}{Q_{inhale_{BL}}} \times \frac{Pe_{Total_i}}{Pe_{Total_{BL}}} \times \frac{\Delta t_i}{\Delta t_{BL}} \times \frac{Variant_{Adj_i}}{Variant_{Adj_{BL}}} \times \frac{Immunity_{Adj_i}}{Immunity_{Adj_{BL}}} \times \frac{Test_{Adj_i}}{Test_{Adj_{BL}}}$$

- $\bar{D}_{mass}$: Dose of inhaled contaminant (quanta)
- φ: Likelihood that any individual member of the group is infectious at the start of the scenario or modeled event (dimensionless)
- $\dot{M}$: Emission rate of contaminant (quanta/hour)
- $Pe_{Emitting}$: Number of emitting people (i.e., number of potential sources) in the group. (#)
- FF_{Factor}: Far Field Factor ($[m^3/hour]^{-1}$)
- NF_{Factor}: Far Field Factor ($[m^3/hour]^{-1}$)
- Ef_{out}: Bulk mass efficiency of mask during exhalation for contaminant (dimensionless)
- Ef_{in}: Bulk mass efficiency of mask during inhalation for contaminant (dimensionless)
- Q_{inhale}: Inhalation Rate (m^3/hour)
- Pe_{Total}: Total number of people in the group (#)
- Δt: Duration of exposure (hour)
- $Variant_{Adj}$: Adjustment for higher transmission rate of variants as compared to wild type virus (dimensionless)
- $Immunity_{Adj}$: Adjustment for the rate of immunity and efficacy of immunity among the community or group (dimensionless)
- $Test_{Adj}$: Adjustment for the efficacy of test regimes used for a group (dimensionless)
- BL: Indicates baseline variable
- i: Indicates value for the evaluated scenario

B Individual Dose Ratio

(Eq. 4)

$$\frac{\bar{D}_{\text{quanta } i}}{\bar{D}_{\text{quanta } BL}} = \frac{\varphi_i}{\varphi_{BL}} \times \frac{\dot{M}_i}{\dot{M}_{BL}} \times \frac{\sum_1^{Pe-1}(FF_{Factor\,i} + NF_{Factor\,i})}{\sum_1^{Pe-1}(FF_{Factor\,BL} + NF_{Factor\,BL})} \times \frac{(1 - Ef_{out})_i}{(1 - Ef_{out})_{BL}} \times \frac{(1 - Ef_{in})_i}{(1 - Ef_{in})_{BL}} \times \frac{Q_{inhale_i}}{Q_{inhale_{BL}}} \times \frac{\Delta t_i}{\Delta t_{BL}} \times \frac{Variant_{Adj_i}}{Variant_{Adj_{BL}}} \times \frac{Immunity_{Adj_i}}{Immunity_{Adj_{BL}}} \times \frac{Test_{Adj_i}}{Test_{Adj_{BL}}}$$

C Individual Dose

(Eq. 5)

$$\bar{D}_{\text{quanta } i} = \varphi_i \times \dot{M}_i \times \sum_1^{Pe-1}(FF_{Factor\,i} + NF_{Factor\,i}) \times (1 - Ef_{out})_i \times (1 - Ef_{in})_i \times Q_{inhale_i} \times \Delta t_i \times Variant_{Adj_i} \times Immunity_{Adj_i} \times Test_{Adj_i}$$

D Individual Dose with One Index Case, No Masking

(before variant emergence, vaccination, and use test protocols)

(Eq. 6)

$$\bar{D}_{\text{quanta } i} = \varphi_i \times \dot{M}_i \times \sum_1^{Pe-1}(FF_{Factor\,i} + NF_{Factor\,i}) \times Q_{inhale_i} \times \Delta t_i$$

$$\varphi_i = 1/(Pe_{total\,i} - 1)$$

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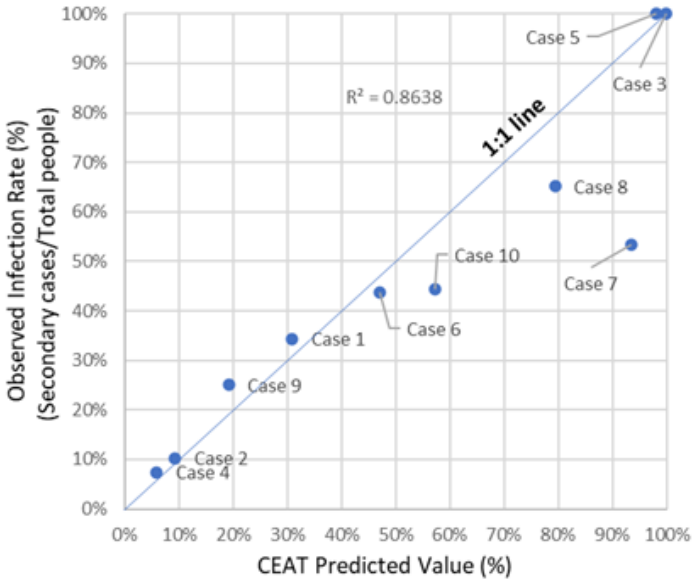
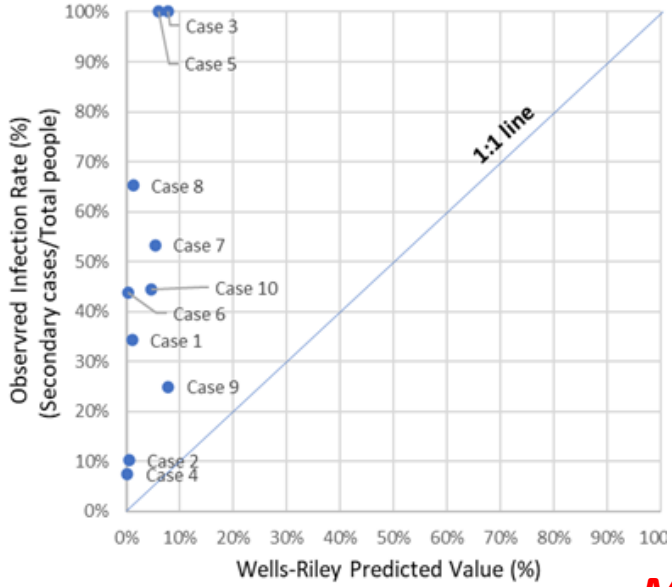
Validation of the CEAT Model

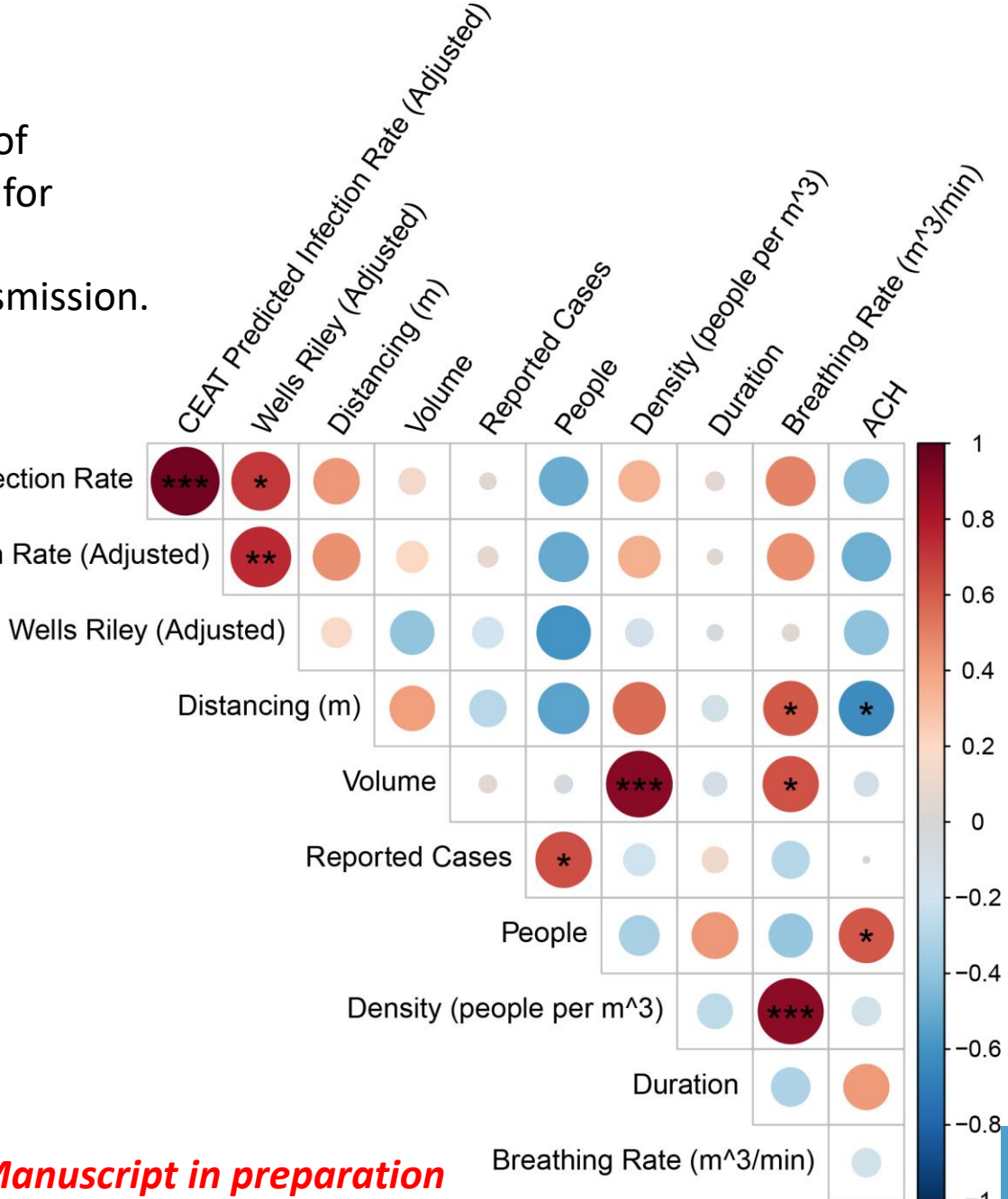
Comparing CEAT model to the standard model Wells-Riley Model:

- The Wells-Riley model is a simple model of the airborne transmission of infectious diseases, developed by William F. Wells and Richard L. Riley for tuberculosis and measles.
- Current model being used by others to assess COVID and aerosol transmission.

CEAT is a far superior predictor of exposure, compared to the model currently being utilized!!!







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Validation of the CEAT Model

COVID-19 Internationa

Comparing

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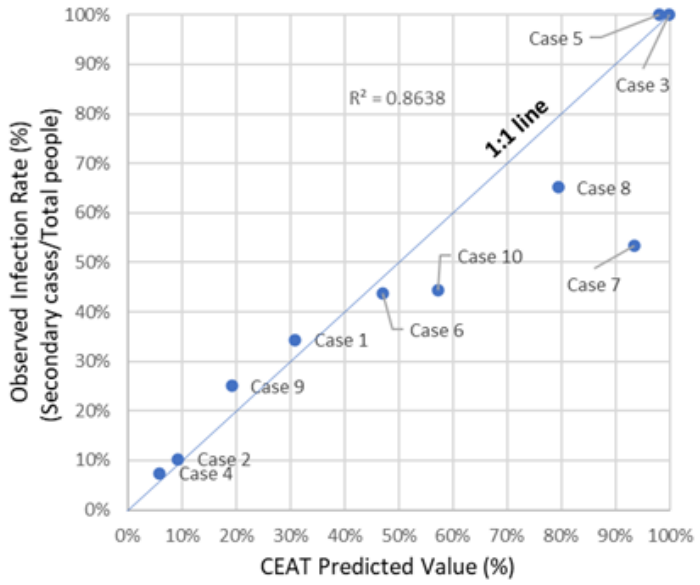
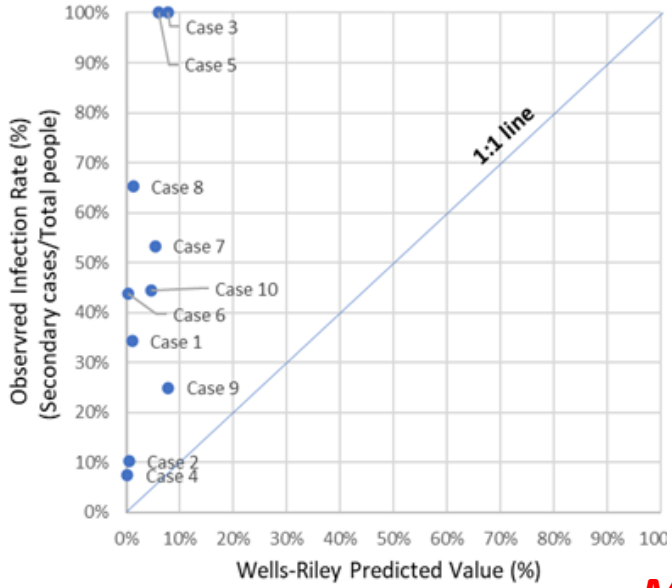
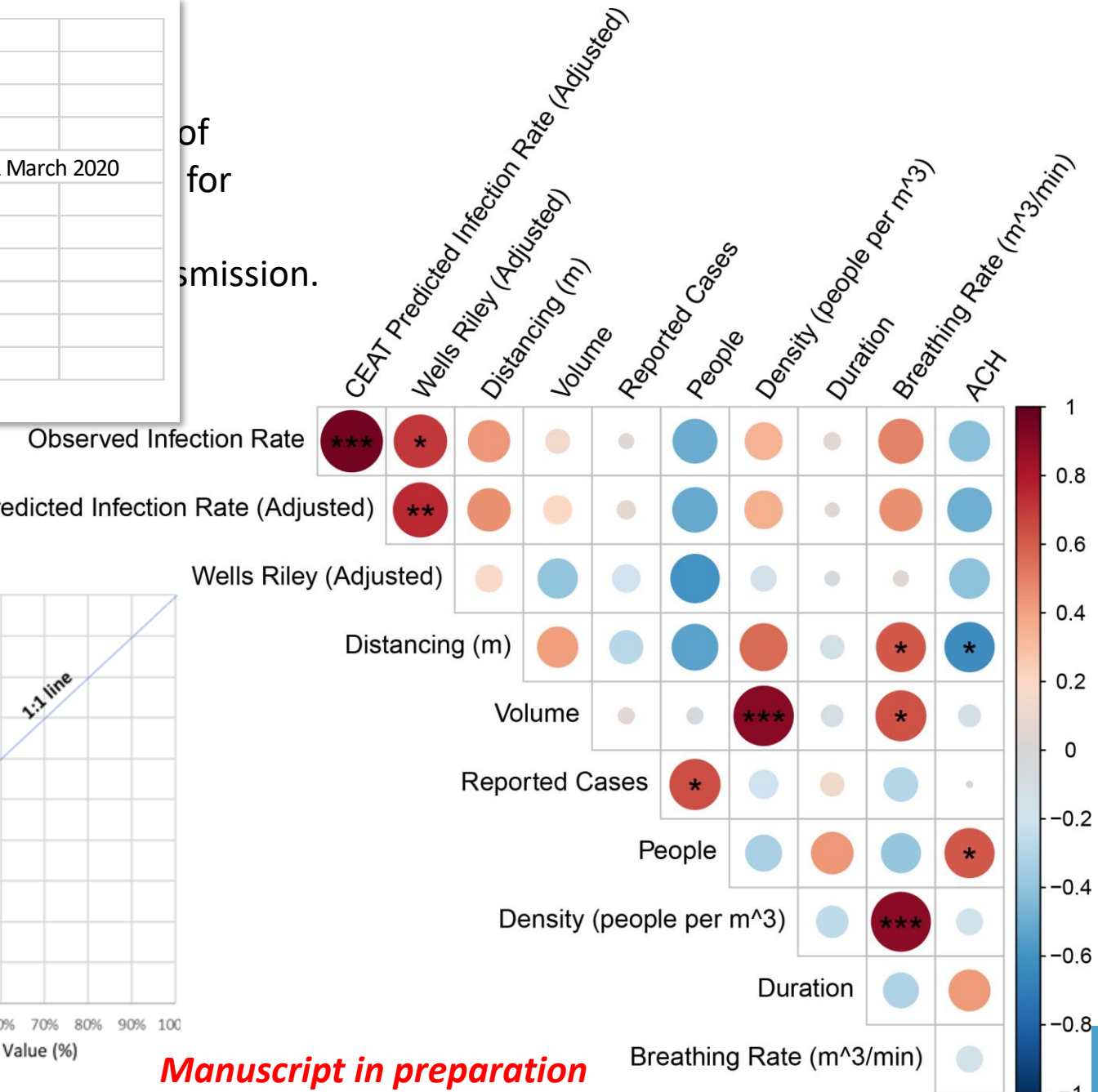
  infectiou … for
  tubercul
- Current … smission.

Case	Description
Case 1	Bus, Zhejiang Province, China, 19 Jan 2020
Case 2	Restaurant, Guangzhou, China, 24 Jan 2020
Case 3	Meeting, Munich, Germany, 21 February 2020
Case 4	Commecrcial Aircraft, Flight VN54 (London, UK - Hanoi, Vietnam), 1 March 2020
Case 5	Recreational Squash, Maribor, Solvenia, 4 March 2020
Case 6	Call Center, South Korea, 8 March 2020
Case 7	Choir Rehearsal, Skagit Valley, WA, USA, 10 March 2020
Case 8	Recreational Hockey, Tampa Bay, Florida USA 16 June 2020
Case 9	Restaurant, Jeonju, South Korea, 17 June 2020
Case 10	Court Room, Vaud, Switzerland, 30 Sep 2020

CEAT is a far superior predictor of exposure, compared to the model currently being utilized!!!







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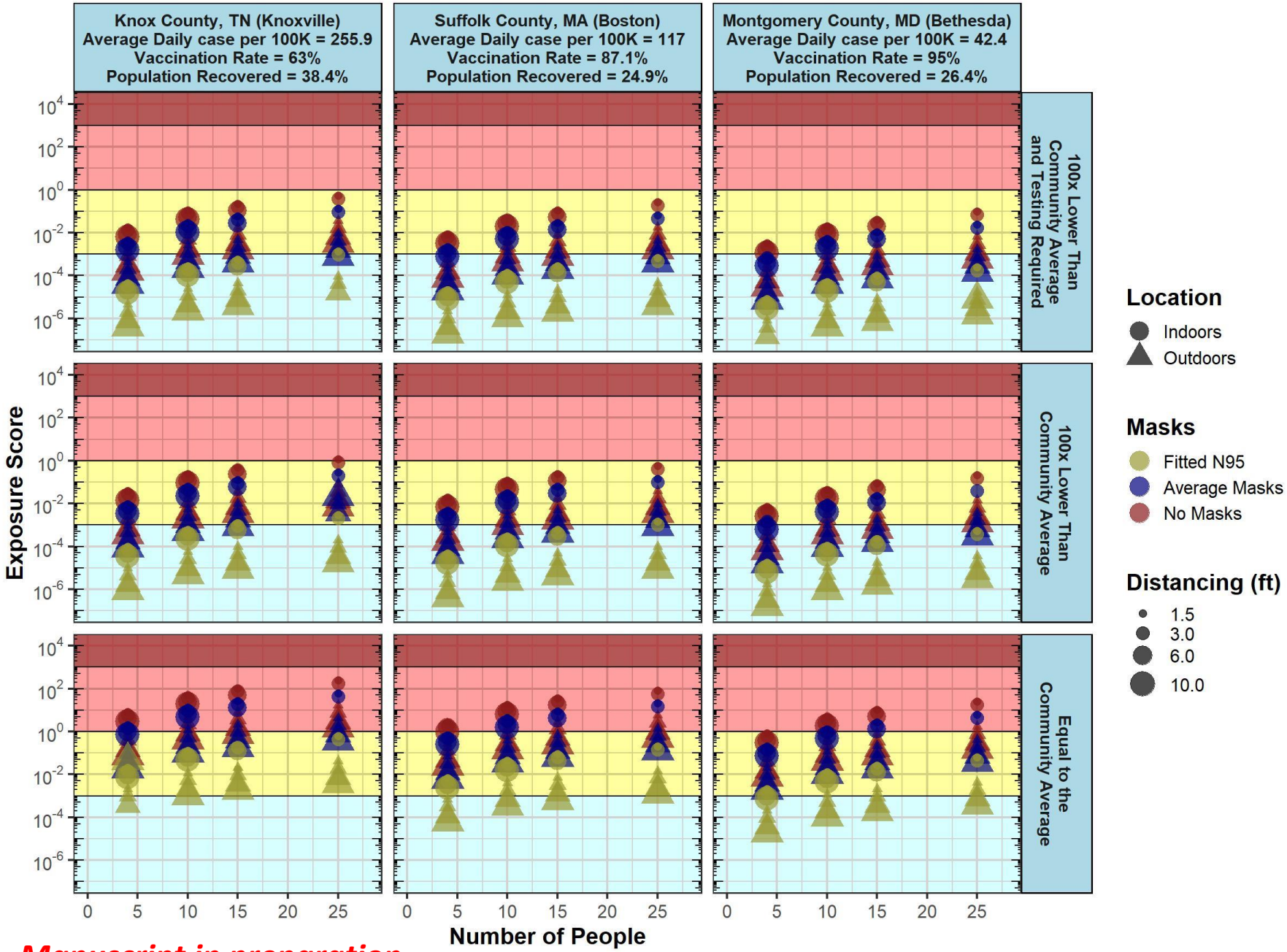
COVID-19 Exposure Assessment for Gatherings of 5 hours

Very High Risk, **High Risk**, **Medium Risk**, **Low Risk**



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Data from 1/31/2022

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Institutions Currently Using CEAT

NASA Centers Currently Using CEAT

SILICON VALLEY

AMES RESEARCH CENTER

Photo Credits: NASA
https://www.nasa.gov/centers/ames/about/overview.html

Photo Credits: NASA
https://www.nasa.gov/feature/nasa-glenn-research-center-s-80th-anniversary-student-essay-contest/

Photo Credits: NASA
https://www.nasa.gov/centers/armstrong/Features/ArmstrongNewSigns.html

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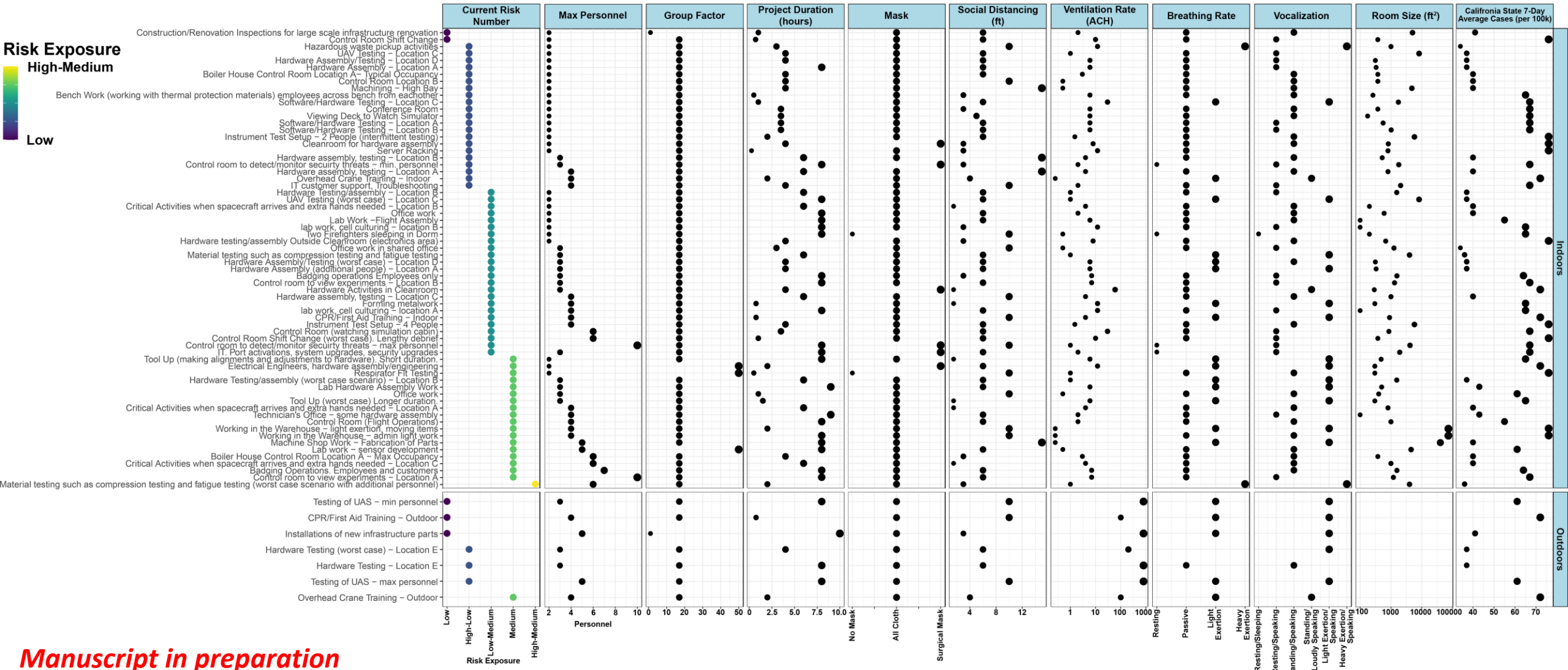
NASA Ames Research Center Example for Utilizing CEAT to Reducing COVID-19 Exposure for Employees



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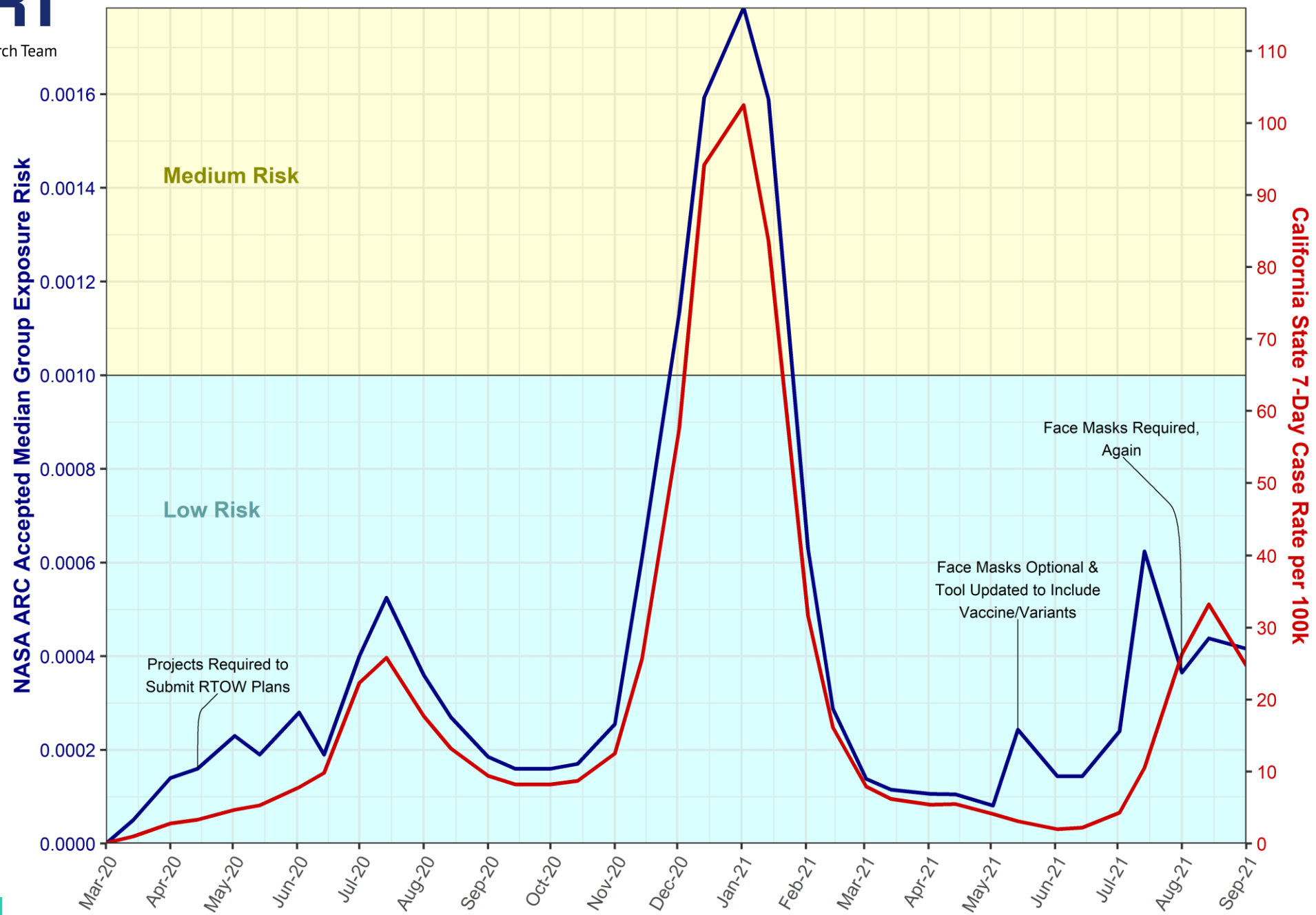
NASA Ames Research Center Accepted Exposure Risk in Relation to Community Case Rates



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KBR — We Deliver

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